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Response of disturbance-dependent breeding bird communities to two site preparations in loblolly pine plantations

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RESPONSE OF DISTURBANCE-DEPENDENT BREEDING BIRD COMMUNITIES TO TWO SITE PREPARATIONS IN LOBLOLLY PINE PLANTATIONS

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ABSTRACT

Disturbance-dependent birds throughout the United States have recently experienced significant declines due to fire suppression and conversion of wilderness to human-dominated landscapes. In Louisiana, young loblolly pine plantations are an important source of early-successional habitat for these specialist birds. However, changes in management practices may affect forest stand suitability for bird communities that rely on them. Here I examined how changes in two site preparations, tree row spacing [14 ft (4.3 m) vs. 20 ft (6.1 m)] and arrangement of post-harvest woody debris (piled vs. scattered), impacted breeding, disturbance-dependent birds. During four summers in 2006-2010, observers conducted point counts and extended searches to determine species richness, abundance, and breeding activity for birds using 0-5 year old plantations at four locations across Louisiana. Vegetation measurements were also recorded and reduced to three composite variables: structure, evergreen cover, and groundcover, to determine how they might influence birds. Although bird communities increased by all measures as stands matured, I found no evidence that they were impacted by any of the experimental site preparations. Similarly, no vegetation measures differed among treatments, although they were highly influential to birds. It appears that bird communities responded positively to increases in vegetation structure, evergreen cover, and groundcover over time as plants became established and breeding resources increased, regardless of either row spacing or woody debris placement. Therefore, it does not appear that row spacing or debris distribution in this study is an important consideration relative to disturbance-dependent bird communities. Due to the importance of vegetation structure and cover to these birds, however, timber managers should employ other methods that maximize non-competitive vegetation, such as thick herbaceous groundcover, to improve habitat quality for disturbance-dependent birds.

CHAPTER 1. INTRODUCTION

Overview

One hundred fifty years ago the southeastern United States was dominated by longleaf pine (*Pinus palustris*) savannahs- large expanses of open pine forest with rich herbaceous understories that spanned along uplands from North Carolina to Texas nearly without interruption. Today less than 4 % of this native habitat remains (Brawn et al. 2001). Similarly, tallgrass prairie in the United States covers 2 % of its recorded range in the 1800s (North American Bird Conservation Initiative 2009). Historically, these habitats were maintained by regular burning from natural and anthropogenic sources, which prevented encroachment of woody vegetation and retained habitat conditions in an early-successional state. These and other disturbance-dependent habitats, such as shrub-scrub, have been seriously reduced in size by the spread of human-dominated landscapes, fire suppression, and lack of active timber harvest, so that now they are recognized as “critically uncommon” in the United States (Beissinger et al. 2000, Trani et al. 2001, North American Bird Conservation Initiative 2009).

Understandably, birds specialized to live in these habitats have similarly suffered reduction in numbers and are considered the most threatened group of birds in the United States, with 56% of grassland species, 39% of shrub-scrub species, and 33% of savannah species experiencing significant declines in in the last 45 years (Brawn et al. 2001, North American Bird Conservation Initiative 2009). Some endemics, such as the Red-cockaded Woodpecker (*Picoides borealis*), are already listed as endangered and many more are designated species of conservation concern by the U.S. Fish and Wildlife Service (2008).

Fortunately, some of these historically disturbed habitat types have been replaced by anthropogenic landscapes that can emulate the original early-successional structure. In the

southeastern United States, one important source of disturbance is timber harvest, particularly within intensively managed timberlands. Pine plantations (*Pinus* spp.) in this region consist of a matrix of forest stands of varying ages, which includes newly cleared areas that provide grassland and shrub-scrub habitat conditions. In the southeastern United States, these plantations account for 20% of forest cover, with loblolly pine (*P. taeda*) accounting for 13.4 million ha (Schultz 1997, US Forest Service 2008). As mature stands are harvested, they are replanted with new seedlings, creating patches of land that remain open to sunlight and attract disturbance-dependent birds for at least the first five years of growth (LeGrand et al. 2007). Indeed, these fabricated, early-successional habitats often support more individuals of more species than their natural counterparts, especially when even-age management is employed (Dickson et al. 1995, DeGraaf 1991, Thompson et al. 1993, Brawn et al. 2001, Keller et al. 2003). Because timber plantations help prevent land conversion to more intensive anthropogenic uses, they are critical for disturbance-dependent birds (Brawn et al. 2001, North American Bird Conservation Initiative 2009).

These anthropogenic habitats types are not all created equal, however. To optimize harvest yields while taking into account desired products (i.e., sawtimber vs. pulp wood), timber managers must account for regional differences in climate, ecology, and soil, tailoring management practices to fit local growth conditions. As such, there exist numerous, localized management strategies that can affect habitat suitability for avian communities (Kilgo et al. 2000). Birds use cues such as vegetation structure and composition, as well as density of conspecifics and heterospecifics, to choose breeding territories. These factors can vary drastically by region, and may affect birds more than management strategies employed in a particular location (DeGraaf 1991, Brawn et al. 2001). To understand and improve intensively-

managed timberlands as habitat for disturbance-dependent birds, experimental studies are required to determine individual influences of different management practices, how they interact to affect birds, and how these patterns change by region (Kilgo et al. 2000, Brawn et al. 2001, Miller et al. 2009).

Some information is currently available about the influence of timber management on bird communities. For example, studies show that species richness is higher in even-age forest stands than in mixed-age stands (DeGraaf 1991, DeGraaf & Yamasaki 2003). Where managers apply herbicide to inhibit growth of competing woody vegetation, the practice simulates disturbance by fire, increasing herbaceous groundcover and prolonging the grassland stage of young stands, which disturbance-dependent birds favor (Guynn et al. 2004). The spacing of the trees themselves could potentially affect birds, as a recent study by Lane (2010) suggests. She found that avian abundance and species richness were higher for the first 6 years of growth when trees were planted further apart, although the study confounded tree spacing and treatment of woody debris left over from the previous harvest.

Woody material left on-site after harvest, known as CWD (coarse woody debris), is very important for birds, providing nesting sites, roosts, and foraging substrate (Horn 2000, Lohr et al. 2002). Stands that retain this resource have as much as 45% more bird species at 50% higher densities compared to those where CWD is shredded or removed (Lohr et al. 2002, Jones et al. 2009). Little is known, however, about how arrangement of post-harvest CWD within a stand might affect bird communities. During site preparation, timber managers must move CWD to make space for tree rows, and if its arrangement is important to birds, studies can suggest arrangements that optimize habitat quality.

As timber managers refine their techniques for maximizing efficiency and wood yield, research is needed to assess the impact new methods have on wildlife. When research by timber managers and wildlife scientists happens concomitantly, recommendations can be made that benefit wildlife before novel strategies are implemented on a large scale. Weyerhaeuser Company, which is the one of the largest industrial landowners in the southeastern United States and the largest in Louisiana, has recently shifted from a 14 ft (4.3 m) to a 20 ft (6.1 m) row spacing to meet the goal of growing quality sawtimber with decreased costs. The company is also examining how different distributions of CWD affect harvest, and how they may interact with row spacing, providing an opportunity to study wildlife responses under these conditions.

Change in row spacing may alter the trajectory of vegetation succession by changing availability of light and soil resources for pines and their botanical competitors. Similarly, moving woody debris into large piles as opposed to leaving it scattered in between tree rows may inhibit deposition of seeds by wildlife (by reducing availability of perches for birds and cache locations for hoarding rodents), reducing hardwood encroachment to the benefit of pine trees and wildlife that prefer open, herbaceous groundcover. To date, no studies have addressed how these specific site preparations or their combination could impact disturbance-dependent bird communities. Because loblolly pine plantations in the southeastern United States are so important to this suite of declining habitat specialists, understanding how these methods could alter early-successional habitat quality is of particular conservation importance.

Objectives

In this thesis, I examined how specific timberland management practices influence habitat quality for disturbance-dependent birds. In particular, I studied effects of row spacing and

woody debris placement on breeding bird communities in 0-5 year old loblolly stands in Louisiana.

My specific research objectives were to:

- Evaluate the response of breeding bird communities to manipulations of row spacing and debris placement during the first five years after stand establishment;
- Investigate the influence of changing vegetation composition and structure on breeding bird communities during this stage;
- Identify any indirect influences of row spacing and debris placement on breeding bird communities by evaluating vegetation response to these site preparations;
- Recommend which combination of site preparations maximizes benefits to early-successional breeding bird communities.

CHAPTER 2. METHODS

Site Characteristics and Treatment Design

We conducted our study at four sites across Louisiana: Winn (A), Jackson (B), Tangipahoa (C), and Washington (D) parishes (Figure 1). These locations roughly represented the north-central and southeastern portions of the state, which were generally the areas most active in loblolly timber production when the study commenced (US Forest Service 2005).

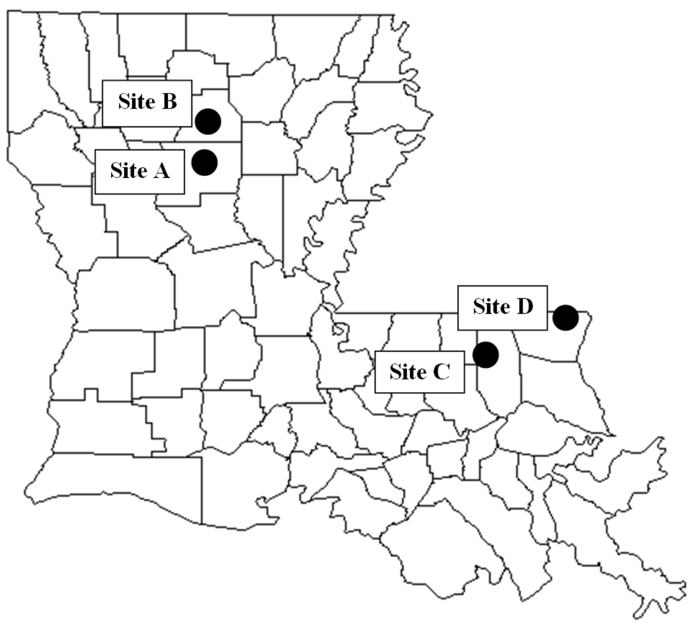

Figure 1. Locations of sites surveyed between late April and early June, 2006-2010, to determine disturbance-dependent bird community response to variation in row spacing and placement of logging debris in loblolly pine plantations in Louisiana, USA

The study sites and most of the surrounding area were owned by Weyerhaeuser Company (hereafter Weyerhaeuser), which is the major landowner in both study regions and the largest industrial landowner in Louisiana. Weyerhaeuser managed the sites for production of sawtimber from loblolly pine and had recently harvested the previous crop as part of their standard 25-32 year rotations. In 2006, the sites were prepared and planted with pine seedlings with summer

2006 as their first growing season. Each site was typically surrounded by a matrix of more mature loblolly stands, rural residences, and low-traffic forest roads. Due to local hydrology, most sites were also either bordered or interlaced with strips of mature forest vegetation left undisturbed as part of streamside management zones (SMZ's).

The sites shared similar annual precipitation and temperature (Table 1), and differed by only 50 m in elevation between the highest point in the north and lowest point in the southeast. Soil characteristics were also similar, with fine, sandy loam being the dominant soil type at all sites (Natural Resource Conservation Service 2009). Despite their climatic and geologic similarity however, soil drainages were disparate, ranging from poorly to well drained.

Table 1. Climate and geological characteristics in 4 loblolly pine stands surveyed to determine disturbance-dependent bird community response to variation in row spacing and placement of logging debris (Natural Resource Conservation Service 2009). Sites are located in north-central and southeastern Louisiana, USA. "Record units" are site designations used by Weyerhaeuser.

Site	Parish	Record Unit	Elevation	Mean Annual Precipitation	Mean Daily Temperatures April - July	Soil Drainage
A	Winn	197	49 m	161 cm	17.7 – 27.5°C	Moderate
B	Jackson	388	82 m	149 cm	17.7 – 27.5°C	Moderate
C	Tangipahoa	443	30 m	167 cm	18.7 – 27.3°C	Poor
D	Washington	130	73 m	184 cm	18.9 – 27.7°C	Well drained

In 2005, Weyerhaeuser began preparing the sites for the next tree crop. Sites were divided into four sections, each to receive a unique combination of row spacing [14 ft (4.3 m) vs. 20 ft (6.1 m)] and woody debris placement (piled or scattered) (Figure 2). Sections were adjacent to one another but separated by roads or SMZ's. For row spacing, the distance between trees within each row was held constant; only the spacing between rows differed from narrow (14 ft) to wide treatments (20 ft). Debris placement treatments involved the orientation of coarse woody debris left over from the previous crop. In "piled" sections, plantation managers mechanically

raked debris into five large piles, which they placed in the center and near the corners, whereas "scattered" sections had woody debris distributed between rows throughout the section. The rows themselves were elevated onto soil beds so that standing water and volunteer vegetation would not interfere with growth of the seedlings. To enhance competitive advantage of the pines further, all sites received a banded application of herbicides Arsenal® AC (4 oz/ac, BASF Corp. Research Triangle Park, NC) and Oust Extra® (2.5 oz/ac, DuPont™ Crop Protection, Wilmington, DE) prior to planting.

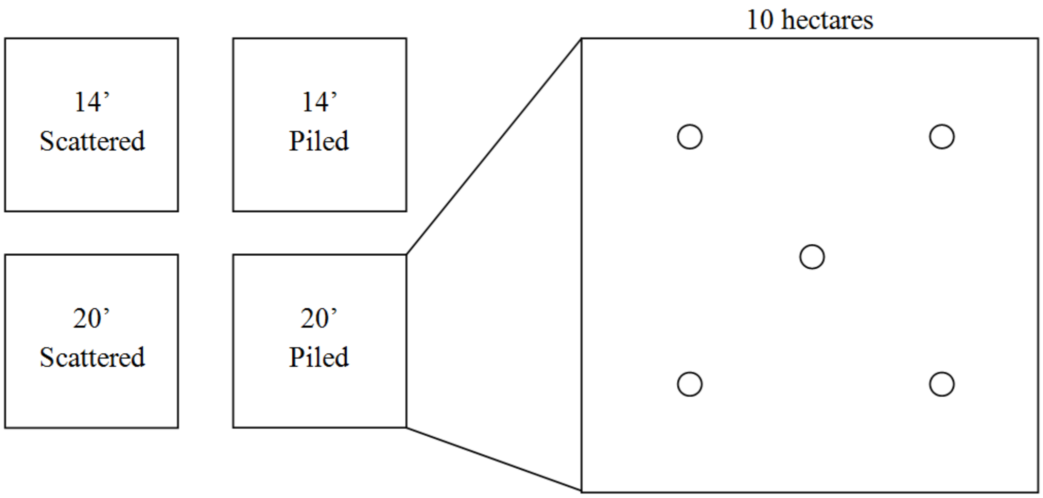

Figure 2. Factorial arrangement of row spacing and debris placement on study plots in 4 loblolly pine stands established in 2005, in north-central and southeastern Louisiana. Circles represent locations of both debris piles on "piled" plots and avian survey points. Orientation of study plots in relation to one another is not accurate.

Once the sites were prepared, single 10 ha study plots were established by Taylor (2008) within each of the four sections of unique treatment combinations. The plots were approximately square to maximize interior area and minimize bisection by SMZ's, although space constraints meant that some plots did contain SMZ's. With four plots at each site, and four sites across Louisiana, the study design totaled sixteen plots with eight replicates of each individual treatment level.

Vegetation Sampling

Vegetation data were collected during the peak growing season (mid-July) in 2006, 2007, 2009, and 2010. My data collection occurred in 2009 and 2010, where data from 2006 and 2007 were taken from a similar but unpublished study (Taylor and Stouffer 2008). Methods of data collection were consistent among years. For simplicity, I will hereafter use "we" when referring to methods employed in both studies.

In each 10 ha study plot, Taylor (2008) established 5 circular vegetation plots, arranged in a line that diagonally bisected the plot. Vegetation plots were 10 m in radius and equally spaced so that combined they stretched the entire length of the study plot (Figure 3). On occasion, our designated plot locations fell on debris piles. In those instances, plots were moved only as far as necessary so that the piles were not inside plots.

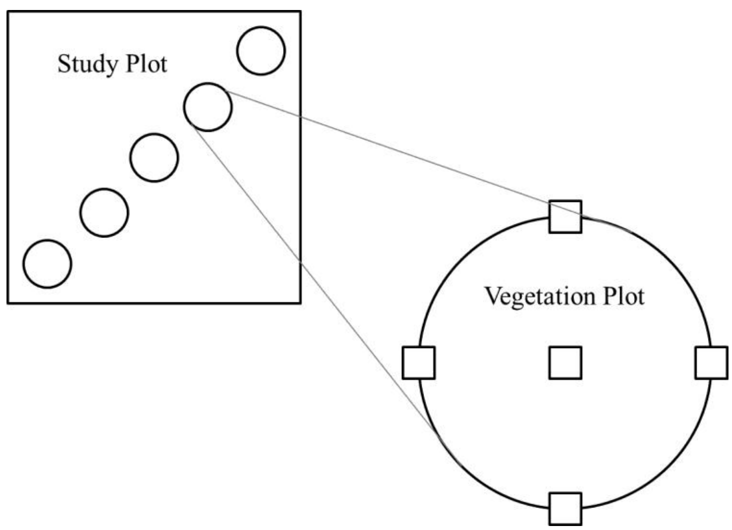

Figure 3. Orientation of vegetation plots within study plots on 4 young loblolly pine stands surveyed in June-July, 2006, 2007, 2009, and 2010, in Louisiana. Small squares are locations where percent cover samples were taken.

Within vegetation plots, observers recorded stem counts, percent ground cover, and height metrics. Stem count data consisted of total live softwood and hardwood stems within the

entire plot, excluding stems that were less than 1 m in height. For percent cover, we used a "Daubenmire" frame to isolate five, 1 m^2 subsamples- one in the center of each plot, and one at its edge in each cardinal direction (Daubenmire 1959) (Figure 3). Ground cover was categorized as fern, yaupon (*Ilex vomitoria*), forb, vine, woody, grass, debris, or bare ground. Because some vegetation could be layered, we allowed total percent cover to exceed 100%. Yaupon was separated from other woody species for its prevalence on the sites as well as its uniquely dense structure. For height metrics, observers used a 1.5 m Robel pole with 0.1 m increments to record maximum and average vegetation height, and vertical obstruction (Robel 1970). With the pole placed in the plot's center, observers stood 10 m away in each of the cardinal directions, recording information based on readings taken from the pole at that distance.

Taylor (2008) and I obtained 13 different measures of composition and structure on 80 vegetation plots each year. To simplify analysis, we averaged values for all variables to the vegetation plot level, resulting in 5 observations per study plot per year, or 40 observations per individual treatment per year.

Avian Surveys

The breeding bird community was surveyed for four breeding seasons after sites were established. The first surveys were conducted at the north-central sites (A & B) in 2006, directly after the plantations were established. These and the remaining sites (C & D) were surveyed in 2007, 2009 and 2010. Data from 2006 and 2007 were collected by Taylor (2008). Within each breeding season, Taylor (2008) and I surveyed each site five times, from late April to early June, which corresponded to the peak of breeding activity for most of the species using the sites. Surveys on a particular site were at least 10 days apart to increase temporal independence. No

surveys were conducted on rainy or windy days, as these conditions suppress bird activity and reduce detectability.

Avian surveys were composed of two parts: point counts and extended searches. On each study plot, Taylor (2008) and I designated five point count locations, corresponding to the center of the plot and its four corners, in an orientation similar to the debris piles on "piled" plots. For piled treatment plots, we moved survey locations just far enough that they did not coincide with the debris piles. To increase the likelihood of sample independence, points were no less than 75 m apart, and no less than 50 m from plot edges. The surveys themselves were based on procedures recommended by the Lower Mississippi Valley Joint Venture (2004), which were adapted from Hamel (1996). Counts involved standing at survey locations and recording all birds seen and heard within a 10 min observation period. Observers noted species, age, sex, distance and direction from point, and any behaviors indicative of breeding, such as males defending territory or birds carrying nesting material. For these counts, Taylor (2008) and I limited sampling to the period from 15 min before sunrise to 0900, when birds were most active and detectability was highest. In addition, to reduce potential effect of time of day, we reversed the sequence point counts were conducted on every visit to a site. Observers conducted extended searches after point counts were complete each morning, spending 1 hr per study plot revisiting each point and looking for additional evidence of breeding activity. Extended searches were usually completed before 1100.

From the point count and extended search data, I calculated four community metrics meant to represent different measures of the stands' habitat quality for breeding birds. These measures include species richness, abundance, breeding activity, and a fourth measure called weighted abundance, which incorporated the conservation value of a species into an estimate of

abundance (Panjabi et al. 2005). To focus analyses purely on the breeding communities using individual plots, I excluded from each metric non-breeding winter residents, passage migrants, flyovers, and species holding territories larger than a single plot. I also excluded birds primarily residing in SMZ's, both because these species were forest interior and edge specialists, and because SMZ's were not present in all plots.

I calculated species richness as the number of unique species observed over all point counts and extended searches in a given year for each plot. Raw richness scores were adjusted with program SPECRICH2, which is based on model M(h) of program CAPTURE, and estimates the number of species present even if not all are detected, assuming that individual species vary in detectability (White et al. 1978, Hines 1996).

For abundance of birds on a plot, I determined the number of individuals per species that were detected on a survey, and then averaged those totals over an entire season. I assumed that on some days, not all individuals residing in a plot were detected, and on some days, more individuals were detected than actually used the plots all season. The former situation can occur when males reduce their singing frequency in order to feed nestlings, and the latter may happen when males are detected before territories are established early in the season. I believe that reporting mean abundance per species over a season is an appropriate way to account for this variation. To acquire total abundance on a plot, I summed mean number of individuals over all species detected, yielding one abundance value per plot per year. It is important to note that abundance values are valid only relative to themselves; abundances are not absolute, and should not be used in comparisons outside this study (MacKenzie and Kendall 2002).

Because sole use of presence and abundance data can be misleading if sites are acting as sinks rather than sources, I included a measure of breeding activity in the analyses (Van Horne

1983, Brawn et al. 2001). I used an index modified from Vickery et al. (1992), which assigns scores to breeding territories based on the strength of evidence that young have successfully fledged from them (Table 2). The original index assigns the lowest score, 1, to territories with aggressive males present for 4 or more weeks. I gave partial scores to territories with males present for as few as 2 weeks to account for territories that may have remained active over a longer period, although no more breeding behaviors were witnessed. The method is limited to non-cryptic species whose young are altricial, and whose breeding behaviors are relatively detectable (Rangen et al. 2000, Rivers et al. 2003). For this reason, I excluded Northern Bobwhite (*Colinus virginianus*) and Ruby-throated Hummingbird (*Archilochus colubris*) from breeding activity measures. As a brood parasite that does not attend to its own young, I also excluded Brown-headed Cowbird (*Molothrus ater*). Vickery et al. (1992) scores are cumulative rather than additive, so the score assigned to each territory was based on the highest evidence of fledged young witnessed over a season. Final community scores were the sum of territory scores for all species in a plot/year. In order to assess breeding activity response of designated species of conservation concern, to be compared against the general community response, I also calculated the individual breeding scores for these species when there were sufficient data.

Because I was attempting to measure habitat quality of different stands for specialists of a threatened habitat, and thus species of special conservation concern, I wanted to include one metric of disturbance-dependent bird communities that incorporated the conservation status of individual species into its calculation. I generated an estimate of abundance that weighted each individual by its regional conservation score (RCS), as defined by Partners in Flight (Panjabi et al. 2005). These scores were calculated for each species as a linear combination incorporating relative density, population trend, population size, threats to breeding, and breeding distribution,

with higher values indicating more at-risk species. By using these scores to weigh individuals in the disturbance-dependent community, I assessed habitat quality for these specialists while giving more importance to those species that are most at-risk. Specifically, I used RCS-b values, which are appropriate for birds on their breeding grounds. Designations of RCS-b apply only for the bird conservation regions (BCRs) they represent, of which there are 37 in the United States and Canada (US Fish and Wildlife Service 2008). For this study, sites fell into two BCR's, the West Gulf Coastal Plain/Ouachitas (sites A & B) and Southeastern Coastal Plain (sites C & D).

Table 2. Revised index of breeding activity, modified from Vickery et al. (1992). "Territorial" refers to males who sing, monitor a distinct area, and act aggressively toward other males.

Rank	Breeding Behavior
0.33	Territorial male present 2 weeks
0.66	Territorial male present 3 weeks
1	Territorial male present 4+ weeks
2	Territorial male and female present 4+ weeks
3	Adults carrying nesting material, found laying or incubating eggs, or diverting attentions away from nest
4	Adults carrying food or fecal sacs
5	Juveniles present

Statistical Analysis

I reduced the 13 vegetation metrics to simpler, uncorrelated variables using principal component analysis (PCA) (PROC FACTOR; SAS Institute Inc., Cary, NC). The resulting components retained important information in the original vegetation data while minimizing noise. To select the number of components to retain, I compared results of Cattell's scree test and the Eigenvalue-one test (Kaiser-Guttman criterion), and interpreted metric correlations, keeping those that explained the most variance and were most biologically meaningful. I then used VARIMAX rotation to increase interpretability of the retained components. I deemed metric

correlations higher than 0.35 to be useful for interpreting which of the original variables were represented in each of the components.

To test influences of the two site preparations, I used analyses of variance (ANOVA) with repeated measures, one with each community metric (species richness, abundance, breeding activity, and weighted abundance) and vegetation component designated as the response variable. I also performed several ANOVA testing breeding activity response of select species to site preparations. For predictor variables, I used row spacing, debris placement, and their interaction as fixed effects, with site designated as the blocked random effect (PROC MIXED; SAS Institute Inc., Cary, NC). Because study plots were sampled repeatedly over four years, I designated year as the repeated measure, specifying autoregressive covariance and the Kenward-Rogers adjustment for degrees of freedom as are appropriate for this type of analysis (Kenward and Roger 1997, Kowalchuk et al. 2004). Parameter estimates were obtained using maximum likelihood estimation. When testing differences in least squared means, I used Tukey-adjusted P-values to reduce the likelihood of a type I error. Finally, I assessed normality of the residuals by examining skewness, kurtosis, normal probability plots, and Shapiro-Wilk test results. When necessary, I used square root transformations to normalize community metrics and vegetation components.

I also tested the response of the four bird community measures and retained vegetation components to the passage of time alone. To do this I ran a series of ANOVA identical with those used to test the effect of site preparation, but with year designated as the fixed effect, rather than a repeated measure. For species of conservation concern that were prevalent enough to test a response in breeding activity to site preparation, I also ran ANOVA with repeated measures identical to those used to test the general community measures. Because data on the breeding

activity for individual species were not available for 2006 and 2007, these ANOVAs only included data from 2009 and 2010.

Next, I conducted a series of analyses of covariance (ANCOVA) with repeated measures to test how avian communities responded to differences in site preparation when vegetation was also included as a predictor (PROC MIXED; SAS Institute Inc., Cary, NC). I used the vegetation components as covariates, keeping debris placement but not row spacing as a fixed effect. I reasoned that although debris piles were not sampled in our vegetation measures, row spacing was represented by proxy in the vegetation data (pine stem counts). Using AIC-based model selection as a basis, I created a set of 14 candidate models representing combinations of site preparations, vegetation components (see results for more details of these variables), and their interactions that might be influential and biologically meaningful to avian communities (Table 3) (Burnham and Anderson 2002). I then performed ANCOVAs for all models in the set, once with each avian community metric specified as the response variable (14 models x 4 response variables = 56 ANCOVA). To insure that candidate sets explained sufficient variation in the data to make them useful, I tested fit of the global models using the chi-square goodness-of-fit statistic, $\hat{c}$. Then I compared model fits within model sets for each community metric, deeming the model with the lowest AIC_C value as the best model, and retaining those with a $\Delta AIC_C < 2$ as competitive with the best model (Burnham and Anderson 2002). Final interpretations of avian community responses to site preparations and vegetation components were based on best models, with competitive models taken into consideration.

Table 3. Set of candidate models used in AIC-based model selection to determine the response of avian communities to debris placement and vegetation characteristics in 4 young loblolly pine stands during late April through early June, 2006, 2007, 2009, and 2010 in Louisiana. “S”, “E”, and “G” represent composite variables “structure,” “evergreen,” and “groundcover,” respectively. “D” represents debris placement, and “*” represents the interaction of two variables.

Model
GLOBAL- D S E G D*S D*E S*E
D S E G
D S E
D S D*S
D S
D E D*E
D E
S E G S*E
S E G
S E S*E
S E
S
E
NULL

CHAPTER 3. RESULTS

Avian Community Summary

Over the four years of surveys, we detected 57 species using the study plots (Table 4). Fifty-six percent (n = 32) of species were disturbance-dependent breeders, which require open, early-successional habitat to raise young. The remaining species were passage migrants, late-departure winter residents, or primarily occupied SMZ's rather than the plantations themselves. Of the disturbance-dependent breeders, 56% (n = 18) showed reproductive activity on study plots and 19 % (n = 6) were designated species of conservation concern in the region they were detected (US Fish and Wildlife Service 2008). We detected an additional species of conservation concern, Sedge Wren (*Cistothorus platensis*), but this was a wintering resident and disappeared from plots after the first survey occasion.

Overall, the most commonly detected species were Yellow-breasted Chat (*Icteria virens*), Indigo Bunting (*Passerina cyanea*), Prairie Warbler (*Dendroica discolor*), Blue Grosbeak (*Passerina caerulea*), and Carolina Wren (*Thryothorus ludovicianus*), which comprised 47 % of detections for all years. In general, the most abundant species were also those actively breeding on the plots, with the next most abundant group being those species that bred in SMZs. These forest and edge species either used the plots immediately after fledging, during unpredictable fledgling movements [Carolina Chickadee (*Poecile carolinensis*), Eastern Bluebird (*Sialia sialis*)], or wandered into plots on rare occasion [Blue Jay (*Cyanositta cristata*), Tufted Titmouse (*Baeolophus bicolor*), Mourning Dove (*Zenaida macroura*)].

As expected, species composition changed as stands matured, with debris-loving species such as Carolina Wren being common in the first two years but declining in subsequent years to be supplanted by shrub-nesting species, such as Yellow-breasted Chat and Prairie Warbler in 2009 and 2010 (Table 4). However, in most cases, species were not replaced by later arrivals but

Table 4: Mean abundance of bird species detected in study plots between late-April and mid-July in 2006, 2007, 2009, and 2010. Species are arranged in order of decreasing total detections. “*” indicates disturbance-dependent species; “†” indicates species breeding on plots, and “¥” indicates species of conservation concern. “P” and “S” refer to piled and scattered debris, respectively, where “14” and “20” refer to row spacing. Conservation score refers to Regional Combined Score for the Breeding Season (RCS-b), as defined by Partners in Flight (2005).

			Mean Abundance																						
	Conservation Score		2006					2007					2009					2010							
Species	Sites A & B	Sites C & D	P 14	P 20	S 14	S 20	%	P 14	P 20	S 14	S 20	%	P 14	P 20	S 14	S 20	%	P 14	P 20	S 14	S 20	%	Total Detected	Years Detected
YBCH*†	13	13	1	1			2	4	7	9	12	8	22	29	28	33	16	28	27	24	36	18	260	4
INBU*†	14	11	3	3	4	6	12	10	17	13	14	14	17	26	22	23	12	23	25	18	21	14	246	4
PRAW*†¥	18	18					0	5	5	6	5	5	18	20	17	19	11	13	12	18	13	9	151	3
BLGR*†	12	12	3		3	6	8	9	9	9	8	9	13	11	10	10	6	8	11	7	8	5	122	4
CARW*†	13	13	3	4	4	4	11	7	8	8	10	9	5	8	4	8	4	4	8	6	6	4	96	4
EATO*†	16	10	1			1	2	7	2	3	4	4	8	11	9	10	5	10	6	10	9	6	92	4
NOCA*†	12	10	4	4	5	2	11	8	2	7	7	6	7	6	6	6	4	7	6	8	7	4	92	4
COYE*†	13	13					0	3	8	5	5	5	7	8	8	9	5	6	5	6	7	4	77	3
OROR*†¥	16	18					0	3	5	6	1	4	9	7	11	7	5	9	7	5	6	4	76	3
EAKI*†	15	13			1		1	3	4	6	7	5	10	4	5	5	3	3	4	1	3	2	55	4
NOMO*†	12	10	1		3		3	2	2	3	4	3	5	6	6	4	3	5	4	7	3	3	54	4
CACH	16	16	2		3	5	8			2	2	1	4	4	3	7	2	6	7	3	6	4	53	4
BHCO*†	8	11					0	4			1	1	8	3	5	5	3	7	8	4	8	4	52	3
WEVI*†	14	16			1	1	2	1	1	2	2	1	5	2	4	4	2	5	5	9	5	4	48	4
MODO*	11	8	1	1	4	1	5	4	3	2	3	3	1	4	1	3	1	3	1	1	1	1	34	4
BGGN*†	11	13		1			1		1	1		1	5	4	4	4	2	3	4	2	2	2	32	4
NOBO*†	16	15					0	1		1	1	1	4	5	4	3	2	2	4	2	2	2	29	3
EABL*	11	11	3	1	1	1	5		3	4	1	2	3	2	4	3	2					0	25	3
FISP*†	15	15					0			1		0	2	3	3	1	1	1	2	6	3	2	22	3
BRTH*	15	13					0		1	1	1	1	2	1	1	4	1	1	2	3	3	1	20	3
BLJA	14	13	1	2	1	2	5				1	0			3		0	2		1	1	1	14	4
TUTI	13	14	3				2					0		3	1	4	1		1		2	0	14	3
SEWR*¥	-	-					0	2	2	2	3	2					0	4	1			1	13	2
RHWO*†¥	15	17			2		1			4	1	1	2	3		2	1					0	13	3
GCFL*	12	13	1		1		2		2			1	1	2	1	1	1	1	1		1	0	12	4
RTHU*	12	13	1			1	2	1	1	1		1		2		2	1	1	1		1	0	12	4

(Table 4 cont.)

	Conservation Score		Mean Abundance																					
			2006					2007					2009					2010						
Species	Sites A & B	Sites C & D	P 14	P 20	S 14	S 20	%	P 14	P 20	S 14	S 20	%	P 14	P 20	S 14	S 20	%	P 14	P 20	S 14	S 20	%	Total Detected	Years Detected
RBWO	13	12			3		2			1		0	1	4			1				2	0	11	4
PIWA	14	14	2				2					0		2	1		0		4		2	1	11	3
SUTA	16	15		1			1	1	2		1	1	2	2			1	1		1		0	11	4
SWSP	-	-					0	2	3	2	2	2					0			1		0	11	2
COGR*	11	11					0	2	2	3	2	2					0	1				0	10	2
GRCA*	11	9					0			1		0	2	2	2		1	1	1			0	9	3
HOWA	14	16			2		2					0		3	1	1	1				1	0	8	3
CGDO*¥	16	11					0		1		1	1	2				0	2				0	6	3
NOFL	15	14					0			1		0	4		1		1					0	6	2
REVI	11	11	3	1	2		4					0					0					0	6	1
AMCR	11	10		1			1					0	1	1	1		0					0	4	2
BHNU*¥	20	19				2	2					0				1	0				1	0	4	3
CHSP*	9	11	1	1			2				2	1					0					0	4	2
HOWR	8	8					0	2	1			1				1	0					0	4	2
RWBL*	11	10					0		1			0		1			0		2			0	4	3
DOWO	14	13					0					0				1	0				2	0	3	2
RTHA	9	9					0	2		1		1					0					0	3	1
SOSP*	8	-				2	2			1		0					0					0	3	2
YTVI	15	15				1	1					0	1				0	1				0	3	3
WTSP	-	-					0	1			1	1					0					0	2	1
AMKE*	13	13					0			1		0					0					0	1	1
AMRO	6	9	1				1					0					0					0	1	1
BACS*¥	21	20					0				1	0					0					0	1	1
CWWI	16	16					0					0	1				0					0	1	1
EAWP	14	16			1		1					0					0					0	1	1
MAWR	14	-					0					0					0			1		0	1	1
TUVU	9	10		1			1					0					0					0	1	1
WITU	11	11					0					0				1	0					0	1	1
YBCU†	15	15					0					0					0				1	0	1	1
YRWA	-	-					0		1			0					0					0	1	1
Total			34	22	39	34	100	83	94	108	106	100	172	190	166	181	100	159	158	143	164	100	1853	

merely surpassed in abundance. For example, although Indigo Bunting and Northern Cardinal (*Cardinalis cardinalis*) were the two most abundant species in 2006 and their numbers increased steadily over the four years, they became less abundant than more numerous species. The species that did stop using plots after the first two years were ground-foraging specialists such as Chipping Sparrow (*Spizella passerina*) and American Robin (*Turdus migratorius*).

Overall, avian community metrics increased with time (Figure 4). As plantations aged, species richness and abundance increased, and although abundance decreased slightly in 2010, breeding activity was higher in this year than any other year. This could be interpreted two ways: either there were actually fewer birds in 2010, and those birds were able to breed with more success than in previous years, or the number of birds did not decrease. A perceived decrease in abundance could be due to decreased probability of detection when birds behave cryptically (as when feeding or incubating young) in thick vegetation. Either way, year was a significant predictor of change for all community metrics, with species richness ($F = 10.92$, $df = 3,53.4$, $P < 0.0001$), abundance ($F = 71.55$, $df = 3,52.3$, $P < 0.0001$), breeding activity ($F = 81.08$, $df = 3,52.3$, $P < 0.0001$), and weighted abundance ($F = 77.83$, $df = 3,52.2$, $P < 0.0001$) all increasing with time.

Vegetation Summary

Among all vegetation plots, we detected 124 separate taxa (genera or species) of plants. Although *Pinus taeda* remained the only softwood species, the sites hosted an array of hardwoods, including natives such as sweet gum (*Liquidambar styraciflua)*, sassafras (*Sassafras albidum)*, red maple (*Acer rubrum),* yaupon holly (*Ilex vomitoria)*, winged sumac (*Rhus copallina)*, and oaks (*Quercus* spp.), as well as non-native invasives such as Chinese privet (*Ligustrum sinense)* and Chinese tallow (*Sapium sebiferum*). The patchy shrub layer was

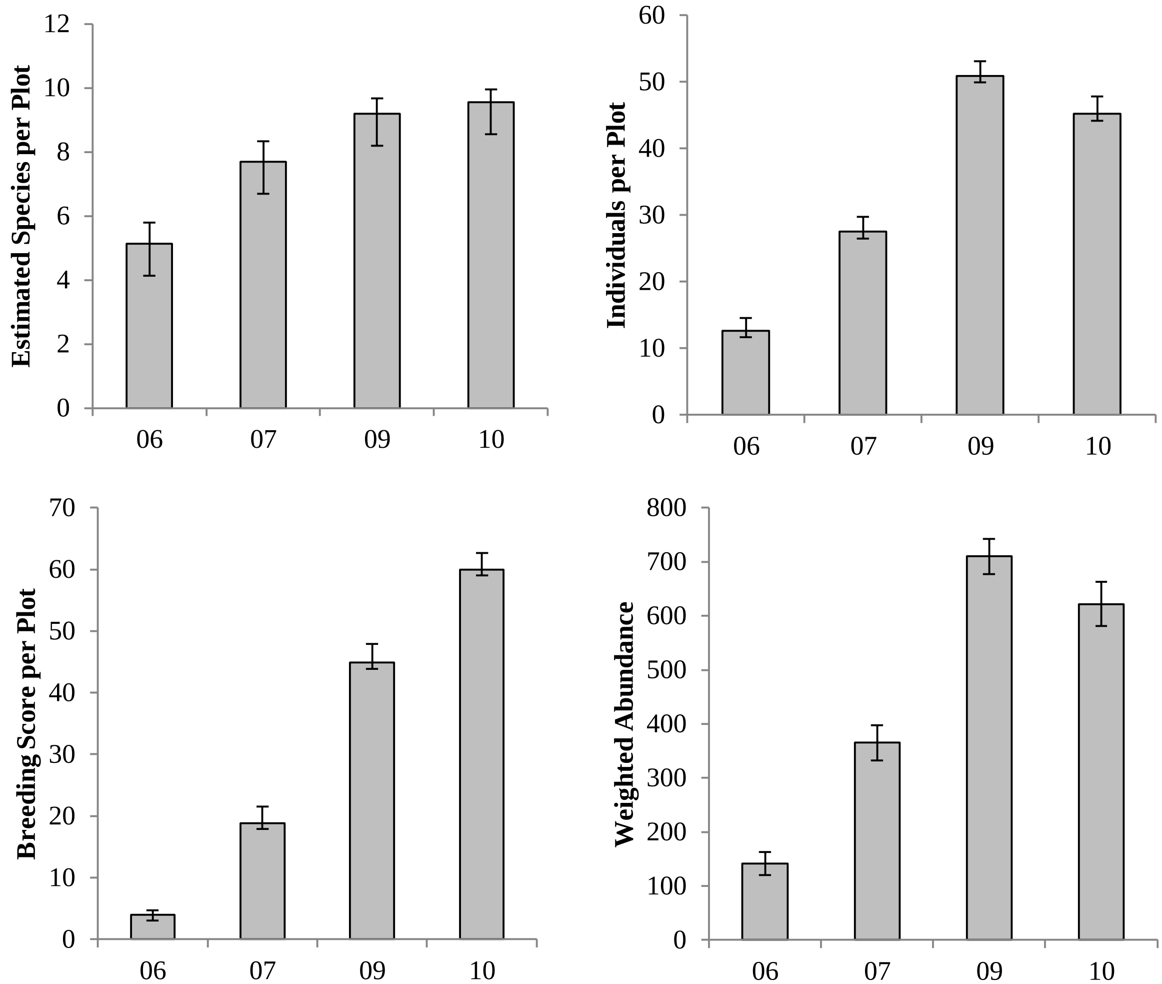

Figure 4: Four measures of disturbance-dependent bird communities in young loblolly plantations in Louisiana. Years represent first (2006), second (2007), fourth (2009), and fifth (2010) breeding seasons (late-April – early-June) post-planting. Error bars represent standard error.

dominated by species such as American beautyberry (*Callicarpa americana*), eastern baccharis (*Baccharis halimifolia*), and swamp titi (*Cyrilla racemiflora*), interwoven with abundant canes of blackberry (*Rubus* spp) and a smattering of greenbriar (*Smilax* spp). Dominant grasses belonged to genera *Andropogon* and *Schizachyrium*, while most forbs were from the genus *Solidago*, *Eupatorium*, *Ambrosia*, or *Aster*. Differences in soil drainage among sites led to differences in dominant species composition, with the wettest, Site C, dominated by lowland hardwood and

freshwater marsh species (*Nyssa* sp and *Saururus cernuus*) while the driest site, D, was characterized by species associated with upland areas (*Ilex vomitoria* and *Anropogon* spp).

Principal Component Analysis of the 13 vegetation measurements (pine and hardwood stem counts, 8 percent ground cover categories, and 3 height measures) yielded three components that satisfied retention requirements, and thus were retained for further analyses. I loosely interpreted these components as overall structure, evergreen cover, and groundcover (Table 5). I chose not to retain the fourth component, although it had an eigenvalue > 1, deeming it biologically unimportant as it only weakly explained the variance in percent cover of ferns and forbs (Table 6).

Table 5: Correlations between retained principal components and original vegetation characteristics measured on 4 young loblolly pine stands during June-July, 2006, 2007, 2009, and 2010 in Louisiana. (*) indicates vegetation characteristics that are highly correlated with a component.

Vegetation Metric	**Structure**	**Evergreen**	**Groundcover**
Pine Stem Count	0.20	0.81*	0.00
Hardwood Stem Count	0.64*	0.50*	-0.50
% Cover Fern	0.19	-0.10	-0.17
% Cover Yaupon	0.30	0.78*	-0.20
% Cover Forb	0.18	0.34	0.24
% Cover Vine	0.49*	0.32	-0.12
% Cover Woody	0.76*	-0.20	-0.90
% Cover Grass	-0.60	-0.11	0.86*
% Cover Debris	-0.60	-0.26	-0.63*
% Cover Bare Ground	-0.54*	0.18	-0.61*
Minimum Height	0.74*	0.48*	0.16
Maximum Height	0.70*	0.43*	0.33
Average Height	0.82*	0.17	0.30
Total Variance Explained	35.00%	13.40%	9.00%

The first principal component, which I referred to as “structure,” represented a gradient between bare ground at one end and tall, dense vegetation at the other. Of the different plant groups, this component mostly encompassed the variation in hardwoods; hardwood stem count

Table 6: Variance explained by principal components derived from 13vegetation characteristics measured on 4 young loblolly pine stands during June-July, 2006, 2007, 2009, and 2010 in Louisiana.

Component	Eigenvalue	Difference	Proportion	Cumulative
1	4.55	2.81	0.35	0.35
2	1.74	0.57	0.13	0.48
3	1.17	0.07	0.09	0.57
4	1.10	0.12	0.08	0.66
5	0.98	0.11	0.08	0.73
6	0.87	0.12	0.07	0.80
7	0.74	0.18	0.06	0.86
8	0.57	0.07	0.04	0.90
9	0.50	0.18	0.04	0.94
10	0.32	0.11	0.02	0.97
11	0.21	0.07	0.02	0.98
12	0.14	0.05	0.01	0.99
13	0.10	0.00	0.01	1.00

and percent of woody cover showed a strong positive correlation with it. The second component represented a gradient of increasing evergreen vegetation; as plant height and density increased, so too did pine stem counts and percent cover of yaupon. Finally, component three, "groundcover," represented a gradient between bare or debris-covered ground and dense grass cover. This, out of the three vegetation components, was the only one to notably change directionality over time; bare ground was common in 2006 gave way to grassy cover in 2007, but then became more prevalent again in 2009 and 2010 (Figure 5). This can be interpreted as the rapid growth of grasses in the first two years with shading out by bushes and saplings in the final years. In contrast, "structure" and "evergreen" show positive trends over the four years. Overall, trends in vegetation with time are positive and significant (structure: $F = 12.88$; $df = 3, 53$; $P < 0.001$; evergreen: $F = 76.04$; $df = 3, 52.5$; $P < 0.001$; groundcover: $F = 14.01$; $df = 3, 52.7$; $P < 0.001$). I found that, although vegetation changed over time, none of the vegetation components differed with either row spacing, debris placement, or the interaction between them (Table 7).

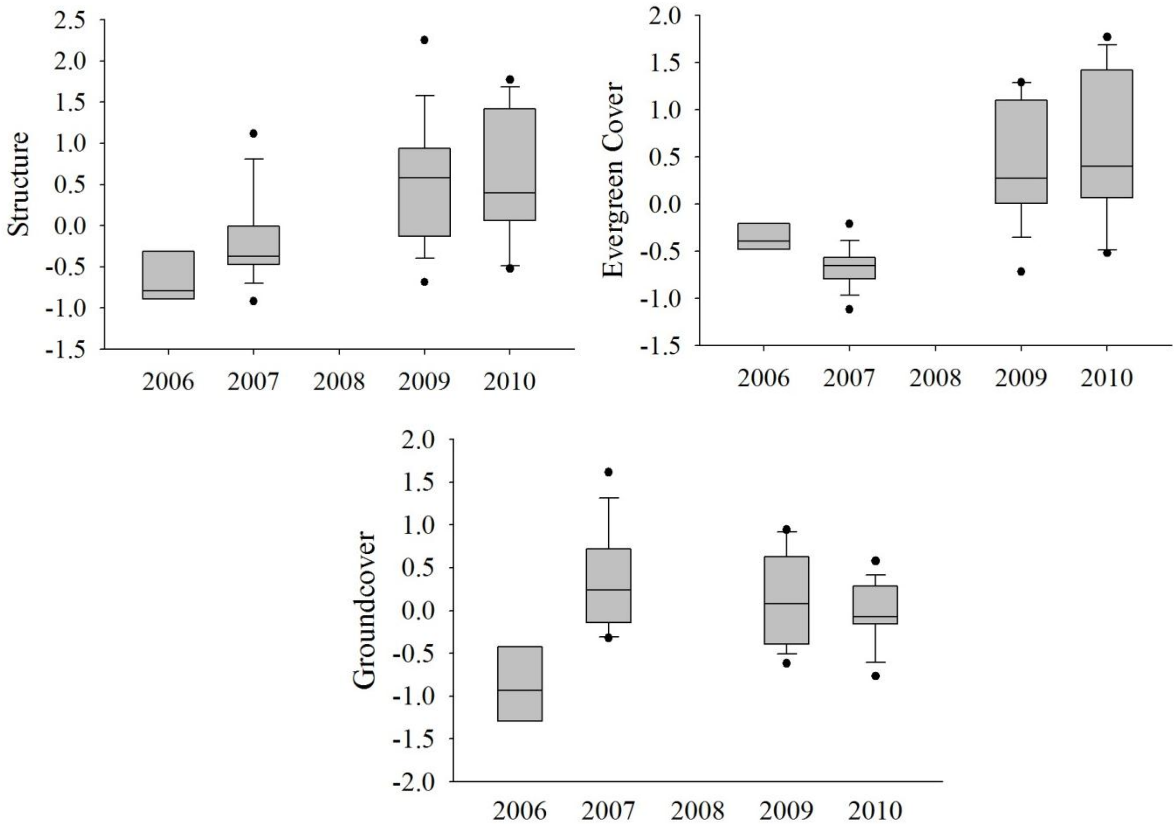

Figure 5: Changes in 3 composite measures of vegetation over time in 4 young loblolly pine stands surveyed June-July, 2006, 2007, 2009, and 2010 in Louisiana. Lower and upper box edges represent 25th and 75th percentiles, while whiskers represent 10th and 90th percentiles, respectively. Lines bisecting boxes represent medians and points are outliers.

Table 7: Analysis of covariance results showing response of vegetation components to site preparations on 4 young loblolly pine stands during June-July, 2006, 2007, 2009, and 2010 in Louisiana. All tests are significant at P < 0.05.

	Structure			Evergreen			Groundcover		
Effect	DF	F Value	P Value	DF	F Value	P Value	DF	F Value	P Value
Debris	1,12.4	0.59	0.46	1,12.3	0.35	0.57	1,12.6	0.04	0.85
Spacing	1,12.4	1.74	0.21	1,12.3	0.59	0.46	1,12.6	1.10	0.31
Spacing*Debris	1,12.4	0.10	0.76	1,12.3	0.13	0.72	1,12.6	0.33	0.58

Avian Community Response to Site Preparations and Vegetation

Similar to the findings on vegetation response, bird communities did not differ based on row spacing, debris placement, or their interaction (Table 8), suggesting that at least at the levels tested, site preparation was not a determining factor in attracting breeding disturbance-dependent birds to stands. Even when breeding activity of designated species of concern was tested at the species level, differences among site preparations were not significant, though only two of these species were abundant enough to include in the analysis (Table 9).

Table 8: Analysis of covariance results showing response of 4 avian community metrics to site preparations on 4 young loblolly pine stands during June-July, 2006, 2007, 2009, and 2010 in Louisiana. All tests are significant at P < 0.05.

		Site Preparation		
Community Metric		Debris	Spacing	Debris*Spacing
Species Richness	DF	1,17	1,17	1,17
	F Value	1.15	0.01	1.7
	P Value	0.30	0.30	0.21
Abundance	DF	1,15.3	1,15.3	1,15.3
	F Value	0.29	0	0.01
	P Value	0.60	1.00	0.94
Breeding Score	DF	1,15.7	1,15.7	1,15.7
	F Value	0	0.01	0.24
	P Value	0.95	0.94	0.63
Weighted Abundance	DF	1,17	1,17	1,17
	F Value	0.15	0	0.02
	P Value	0.70	0.95	0.89

Model selection ranked candidate models based on the likelihood that each one explained the processes governing bird community measures. Top models for all four metrics included “structure” and “evergreen” (Table 10 - 13). Upon examination of model estimates, it is apparent that species richness, abundance, breeding activity, and weighted abundance all significantly increase with increased structure and evergreen cover (Table 14). This can be interpreted as an

Table 9: Analysis of covariance results showing response in breeding of two species of conservation concern to site preparations on 4 young loblolly pine stands during June-July, 2009-2010 in Louisiana. All tests are significant at P < 0.05.

		Site Preparation		
Species		Debris	Spacing	Debris*Spacing
Prairie Warbler	DF	1,12	1,12	1,12
	F Value	0.05	0.06	0.53
	P Value	0.83	0.80	0.48
Orchard Oriole	DF	1,16	1,16	1,16
	F Value	0.07	3.61	0.45
	P Value	0.79	0.08	0.51

overall increase in community diversity and breeding activity as vegetation becomes taller, denser, and more heterogeneous. Groundcover was also influential to all community metrics except species richness. Although the number of species did not increase as plots became grassier, a higher percentage of grass cover supported more individuals and more breeding activity, a logical trend as all of the targeted species use grass stems for nest building. Interestingly, abundance was also influenced by the interaction between structure and evergreen cover, and the trend is positive for abundance but negative when abundance is weighted by the conservation value of each individual. This could be because although taller and more heterogeneous vegetation can support more individuals, the species of highest conservation concern, and thus those weighted most heavily, tended to be those that prefer more open habitat, such as Prairie Warbler and Orchard Oriole. As overall numbers of birds increased with increasing vegetation density, the habitat became less suitable for sensitive, disturbance-dependent species.

Table 10: Model selection results comparing analyses of covariance (ANCOVA) which test response of avian species richness to debris placement and three vegetation characteristics in 4 young loblolly pine stands during late April through early June, 2006, 2007, 2009, and 2010 in Louisiana. "S", "E", and "G" represent composite variables "structure," "evergreen cover," and "groundcover," respectively. "D" represents debris placement, and "*" signifies an interaction between two variables. Competitive models ($\Delta AIC_C < 2$) are marked in bold.

Model	AIC_C	ΔAIC_C	Likelihood	Weight	K	-2loglikelihood
S E	47.89	**0**	1	0.365	3	34.14
S E G	49.07	**1.2**	0.549	0.200	4	32.69
S E S*E	49.35	**1.5**	0.472	0.172	4	32.97
D S E	50.38	2.5	0.287	0.105	5	33.99
S E G S*E	50.92	3	0.223	0.081	5	31.79
D S E G	51.46	3.6	0.165	0.060	6	32.32
E	56.66	8.8	0.012	0.004	2	45.44
D E	57.16	9.3	0.01	0.004	4	43.41
GLOSAL- D S E G D*S D*E S*E	57.15	9.3	0.01	0.004	11	29.01
S	57.78	9.9	0.007	0.003	2	46.55
D E D*E	59.71	11.8	0.003	0.001	6	43.32
D S	60.16	12.3	0.002	0.001	4	46.41
D S D*S	61.29	13.4	0.001	0	6	44.91
NULL	67.97	20.1	0	0	1	59.17

Table 11: Model selection results comparing analyses of covariance (ANCOVA) which test response of avian abundance to debris placement and three vegetation characteristics in 4 young loblolly pine stands during late April through early June, 2006, 2007, 2009, and 2010 in Louisiana. "S", "E", and "G" represent composite variables "structure," "evergreen cover," and "groundcover," respectively. "D" represents debris placement, and "*" signifies an interaction between two variables. Competitive models ($\Delta AIC_C < 2$) are marked in bold.

Model	AIC_C	ΔAIC_C	Likelihood	Weight	K	-2loglikelihood
S E G S*E	147.46	**0**	1	0.912	5	128.39
GLOBAL- D S E G D*S D*E S*E	154.25	6.8	0.033	0.030	11	126.25
S E G	154.54	7.1	0.029	0.026	4	138.21
S E S*E	155.03	7.6	0.022	0.020	4	138.69
D S E G	156.32	8.9	0.012	0.011	6	137.25
S E	162.31	14.9	0.001	0.001	3	148.60
D S E	164.77	17.3	0	0	5	148.43
E	179.90	32.4	0	0	2	168.70
D E	180.25	32.8	0	0	4	166.54
S	181.07	33.6	0	0	2	169.87
D E D*E	182.66	35.2	0	0	6	166.33
D S	183.22	35.8	0	0	4	169.51
D S D*S	184.88	37.4	0	0	6	168.55
NULL	198.60	51.1	0	0	1	189.82

Table 12: Model selection results comparing analyses of covariance (ANCOVA) which test response of avian breeding activity to debris placement and three vegetation characteristics in 4 young loblolly pine stands during late April through early June, 2006, 2007, 2009, and 2010 in Louisiana. "S", "E", and "G" represent composite variables "structure," "evergreen cover," and "groundcover," respectively. "D" represents debris placement, and "*" signifies an interaction between two variables. Competitive models ($\Delta AIC_C < 2$) are marked in bold.

Model	AIC_C	ΔAIC_C	Likelihood	Weight	K	-2loglikelihood
S E G	431.97	**0**	1	0.442	4	415.63
S E G S*E	432.48	**0.5**	0.779	0.344	5	413.42
D S E G	434.54	2.6	0.273	0.121	6	415.48
S E	436.88	4.9	0.086	0.038	3	423.17
S E S*E	436.86	4.9	0.086	0.038	4	420.53
D S E	439.50	7.5	0.024	0.011	5	423.17
GLOBAL- D S E G D*S D*E S*E	440.47	8.5	0.014	0.006	11	412.47
E	463.52	31.6	0	0	2	452.32
D E	464.91	32.9	0	0	4	451.19
D E D*E	467.43	35.5	0	0	6	451.10
S	491.66	59.7	0	0	2	480.46
D S	493.12	61.2	0	0	4	479.41
D S D*S	494.79	62.8	0	0	6	478.46
NULL	506.72	74.8	0	0	1	500.26

Table 13: Model selection results comparing analyses of covariance (ANCOVA) which test response of weighted avian abundance to debris placement and three vegetation characteristics in 4 young loblolly pine stands during late April through early June, 2006, 2007, 2009, and 2010 in Louisiana. "S", "E", and "G" represent composite variables "structure," "evergreen cover," and "groundcover," respectively. "D" represents debris placement, and "*" signifies an interaction between two variables. Competitive models ($\Delta AIC_C < 2$) are marked in bold.

Model	AIC_C	ΔAIC_C	Likelihood	Weight	K	-2loglikelihood
S E G S*E	708.21	**0**	1	0.938	5	689.15
S E S*E	715.79	7.6	0.022	0.021	4	699.46
S E G	716.06	7.8	0.02	0.019	4	699.73
GLOBAL- D S E G D*S D*E S*E	716.43	8.2	0.017	0.016	11	688.43
D S E G	718.25	10	0.007	0.007	6	699.18
S E	724.05	15.8	0	0	3	710.34
D S E	726.64	18.4	0	0	5	710.31
E	744.18	36	0	0	2	732.98
D E	744.43	36.2	0	0	4	730.71
D E D*E	747.05	38.8	0	0	4	730.71
S	750.01	41.8	0	0	2	738.81
D S	751.59	43.4	0	0	4	737.87
D S D*S	753.64	45.4	0	0	6	737.31
NULL	767.78	59.6	0	0	1	76.00

Table 14: Analysis of covariance results for models that best explain the response of 4 bird community measures to debris placement and vegetation characteristics in 4 young loblolly pine stands during late April through early June, 2006, 2007, 2009, and 2010, as determined via model selection. All tests are significant at P < 0.05.

	Influential Variable	Estimate	SE	DF	T value	P value
Species Richness	Intercept	7.56	0.006	3.8	35.71	<.001
	Structure	0.05	0.004	39.7	3.52	0.001
	Evergreen	0.03	0.003	50.3	3.69	<.001
Abundance	Intercept	32.89	0.124	3.9	16.31	<.001
	Structure	0.86	0.018	42.5	6.90	<.001
	Evergreen	0.48	0.012	47.6	6.25	<.001
	Structure*Evergreen	0.36	0.035	52.0	-3.19	0.002
	Groundcover	0.36	0.034	54.0	3.27	0.002
Breeding Score	Intercept	29.96	2.008	4.1	14.92	<.001
	Structure	13.01	1.960	47.7	6.64	<.001
	Evergreen	16.22	1.563	53.7	10.38	<.001
	Groundcover	6.49	2.471	52.8	2.63	0.011
Weighted Abundance	Intercept	480.47	63.073	3.9	7.62	0.002
	Structure	150.61	18.243	40.0	8.26	<.001
	Evergreen	114.49	15.479	44.5	7.40	<.001
	Structure*Evergreen	-90.57	27.231	48.8	-3.33	0.002
	Groundcover	89.95	26.301	49.7	3.42	0.001

CHAPTER 4. DISCUSSION

The site preparations examined in this study seem not to influence, or perhaps did not differ in sufficient magnitude to influence, breeding disturbance-dependent bird communities. By four measures, I found no evidence that community response to 20 ft row spacing differed from 14 ft row spacing, or that response to piled debris differed from scattered debris. This is understandable in light of the evidence that vegetation structure and composition, the primary cues for birds in search of breeding territories, were similarly uninfluenced by these site preparation techniques. Indeed, the only factors that bird communities seemed to respond to were related to vegetation. Patterns showing significant increases in species richness, abundance, breeding activity, and weighted abundance over time can be explained by the fact that the vegetation measures followed the same pattern of yearly increase. Effects of stand age were thus indirect, positively influencing vegetation measures, which in turn directly influenced disturbance-dependent birds, a pattern consistent with other studies (DeGraaf 1991, Keller et al. 2003, Lane 2010).

Aside from a general increase in community measures over time, species turnover was characterized more by addition of species than replacements, with a loss of some ground-foraging species in the first years but a gain in grassland, shrub-scrub, and generalist species as woody and herbaceous resources increased annually. This pattern agrees with other studies examining avian succession after clearcutting, with the expectation that the turnover from early-successional to forest species will begin after canopy closure, sometime between the fifth and tenth year of growth (Keller 2002, LeGrand et al. 2007). At the end of this study, the most sensitive early-successional species, those of conservation concern, were no longer increasing in

abundance, which is likely a first sign of the change in bird community toward forest species that the next several years of stand development will bring.

The few inconsistencies in the community metrics underscore the importance of using multiple measures to assess habitat quality for birds. Most notably, the positive influence of an interaction between structure and evergreen cover on general abundance versus its negative influence on weighted abundance shows that the benefits of increasing vegetation complexity only extend so far. While birds increased their numbers more when structure and evergreen cover increased together than the effect these variables had individually, birds of conservation concern increased less due to the interaction. This is likely because the most sensitive disturbance-dependent species also tend to require more open habitat, meaning that stands are optimally suitable for these birds for a shorter time before vegetation becomes too dense for them to utilize, compared to species with more general requirements. The other inconsistency, a small decrease in bird abundance in the last year (2010) compared to the consistently positive trends in species richness and breeding activity probably stems from birds' increased ability to hide in the thick vegetation that was characteristic of plots in the later years. It is likely that individual birds became more cryptic as stands matured, making measures other than abundance all the more important for an accurate understanding of bird community dynamics.

This study focuses heavily on community-level trends, but it is important to note that grouping entire communities of species, especially when making management recommendations, has its limitations. The species belonging to these communities differ in preferred foraging substrate, preferred nesting substrate, and level of specialization, and that variation is easy to ignore when community-level metrics are used. Land managers require information that enables them to manage for as many species as possible, but when particular species become a special

concern, species-level studies can be valuable aids in tailoring management strategies to their special needs. I did not find evidence that species of conservation concern responded to site preparations differently than communities as a whole, but this does not reduce the importance of attending to variation on the species or guild level.

Based on these results, I can only recommend that Weyerhaeuser implement the combination of row spacing and debris placement that maximize benefits to the pine trees, as disturbance-dependent birds seem not to be affected by those treatments tested in this study. Although Lane (2010) found that birds benefited from wider row spacing in North Carolina loblolly plantations, the difference in spacing [10 ft (3.0 m) and 20 ft (6.1)] was nearly twice that tested here [14 ft (4.3 m) and 20 ft (6.1 m)] and row spacing was confounded with CWD management strategy. It is possible that a repeated study in Louisiana using 10 ft (3.0 m) and 20 ft (6.1) spacing could reveal a similar pattern, but these are not the spacings Weyerhauser intends to implement in this state. Because disturbance-dependent birds did benefit by general Structure, evergreen cover, and grass cover, other site preparations that positively influence these vegetation characteristics could improve habitat quality for disturbance-dependent species. The first two should be easily managed because they correspond well with growth of pine structure, which is the primary goal of timber managers. Increasing grass cover as well benefits both disturbance-dependent birds and pines, the former enjoying open, sunny habitat while the latter is freed from resource competition with other woody species.

Although these findings revealed no influence of site preparation on birds, the stands in this study are young. As turnover in the bird community occurs over time and forest specialists begin to replace early-successional species, community responses to row spacing and debris arrangements may present themselves. For example, it is possible that wider row spacing will

affect the timing of canopy closure, extending the early-successional phase of stands, and allowing them to provide habitat for a longer period. Therefore, it is important to continue monitoring these stands through the full period of maturation in order to understand all of the ways possible that bird communities could be affected by site preparation.

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APPENDIX

Appendix 1. Avian community metrics describing disturbance-dependent birds breeding in 4 young loblolly pine stands during late April through early June, 2006, 2007, 2009, and 2010 in Louisiana. Plot treatments are a combination of piled (P) or scattered (S) debris and 14 ft (4.3 m) or 20 ft (6.1 m) row spacing.

Year	Site	Plot Treatment	Species Richness	Abundance	Breeding Score
06	A	P 14	5	4	5.33
06	A	S 14	5	15	6.94
06	A	S 20	7	18	6.28
06	A	P 20	7	6	1.32
06	B	S 14	7	12	1.98
06	B	P 14	5	20	3.96
06	B	S 20	3	12	3.97
06	B	P 20	2	14	2.31
07	A	P 14	5	10	2.31
07	A	S 14	5	24	18.19
07	A	S 20	8	29	15.23
07	A	P 20	7	19	9.59
07	B	S 14	8	21	8.27
07	B	P 14	5	22	14.26
07	B	S 20	6	33	24.50
07	B	P 20	7	16	12.58
07	C	P 20	10	38	37.79
07	C	S 20	8	30	25.79
07	C	S 14	15	44	37.42
07	C	P 14	6	24	20.53
07	D	P 14	7	39	34.20
07	D	S 14	11	29	11.89
07	D	S 20	7	31	15.88
07	D	P 20	8	31	13.58
09	A	P 14	12	34	17.66
09	A	S 14	9	53	34.00
09	A	S 20	9	39	53.32
09	A	P 20	9	40	33.00
09	B	S 14	6	51	31.99
09	B	P 14	6	50	34.98
09	B	S 20	10	53	54.33
09	B	P 20	14	58	55.33
09	C	P 20	8	45	42.64
09	C	S 20	8	49	60.98
09	C	S 14	9	48	42.99
09	C	P 14	8	53	48.97
09	D	P 14	9	56	57.66
09	D	S 14	10	59	41.00

(Appendix 1 cont.)

Year	Site	Plot Treatment	Species Richness	Abundance	Breeding Score
09	D	S 20	10	58	51.99
09	D	P 20	10	69	57.31
10	A	P 14	8	37	69.99
10	A	S 14	11	36	55.65
10	A	S 20	9	25	54.97
10	A	P 20	8	35	43.66
10	B	S 14	9	40	68.97
10	B	P 14	9	42	54.99
10	B	S 20	8	48	50.98
10	B	P 20	7	40	57.00
10	C	P 20	11	46	42.32
10	C	S 20	10	43	66.99
10	C	S 14	9	43	47.32
10	C	P 14	8	52	66.33
10	D	P 14	11	60	80.65
10	D	S 14	12	62	65.97
10	D	S 20	12	62	65.98
10	D	P 20	11	52	68.3

VITA

Falyn L. Owens was born in Denver, Colorado, in 1984. She spent the majority of her formative years in coastal Virginia, near the marshes and beaches bordering the Chesapeake Bay. From an early age, she showed devotion to natural resource conservation, volunteering her summers from the age of 14 at the Virginia Living Museum, where she helped care for rehabilitated wildlife and teach patrons basic astronomy. Finishing high school as salutatorian of her graduating class, she entered college intent on becoming an ornithologist. In those four years, she studied animal science and botany in South Africa, met her life partner, and earned her Bachelor of Science degree in biology from the University of Mary Washington, near Washington, D. C. After two years working as a horticulturist for the Virginia Living Museum and as a bartender, she stepped into the wild world of field biology and has never looked back. She hopes one day to find a niche connecting conservation science with public outreach and education. When not pursuing that goal, Falyn likes to seek adventure and taste-test microbrews with friends.